I. MICROSCOPICAL TUBE-LENGTH,

And the Parts Included in it by the Various Opticians of the World.

II. THE THICKNESS OF COVER-GLASS

For which Unadjustable Objectives are Corrected.

SIMON H. GAGE, Ithaca, N. Y.

I. In the construction of microscopic objectives, the corrections must be made for the formation of the image at a definite distance, or, in other words, the tube of the stand of the microscope on which the objective is to be used, must have a definite length. Consequently, the microscopist must know and use this distance or "microscopical tube-length" to obtain the best results in using the objective in practical work.

In order to ascertain the exact distance in millimeters for which objectives are corrected, and the parts of the microscope included in this distance or "tube-length" the following questions were submitted to all the opticians of the world whose address could be obtained: 1. For what "tube-length" do you correct your microscopic objectives? Please give the length in millimeters or inches. 2. Please indicate on the diagram on the opposite page (Fig. 1. of this paper) exactly what parts of the microscope you include in "tube-length." From nearly all, precise and satisfactory answers were received, and I wish to express here my appreciation of their courtesy. The answers received are given below, and indicated on the accompanying diagram:

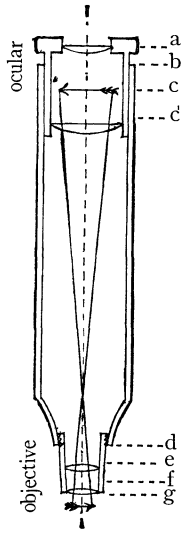

Table giving length in millimeters and figure showing parts included in "tube-length" by various opticians.

Pts. included in "Tube-lengths." See Diagram.		"Tube-length" in Millimeters.
a–d	Grunow, New York	203 mm.
	Nachet et Fils, Paris	146 or 200 mm.
	Powell and Lealand, London	254 mm.
	C. Reichert, Vienna	160 to 180 mm.
	W. Wales, New York	254 mm.
b–d.....	Bausch & Lomb Opt. Co., Rochester	216 mm.
	Bézu, Hausser et Cie., Paris*	220 mm.
	Klönne und Müller, Berlin	160–180 or 254 mm.
	W. & H. Siebert, Wetzlar	190 mm.
	Swift & Son, London	165 to 228½ mm.
	C. Zeiss, Jena	150 or 250 mm.
a–g.....	Gundlach Optical Co., Rochester	254 mm.
c–d.....	Ross & Co., London	254 mm.
c–e.....	R. & J. Beck, London	254 mm.
c–g.....	H. R. Spencer & Co., Geneva, N. Y.,	254 mm.
c–f.....	J. Green, Brooklyn †	254 mm.
c'–e....	E. Leitz, Wetzlar	125–180 mm.
	For oil immersions	160 mm.

*Successors to Hartnack.
†Successor to Tolles.

A glance at the table and diagram is sufficient to show that there is about as great diversity as possible in the parts included in "tube-length," and that the length in millimeters including these parts, is likewise very diverse. This has, doubtless, come about simply because there was no general standard, and each optician selected for himself a standard. For the sake of those who *use* the microscope, it is hoped that a uniform standard may be chosen, or that, at most, but two standards should be decided on by all opticians. These two lengths in millimeters would probably best be 254 mm. for the long or English "tube-length," and 160 mm. for the short or Continental "tube-length." Furthermore, the same parts of the microscope should be included in the "tube-length," and the parts included should be readily determinable by the youngest student. The parts included by six of the opticians named above, viz: from the top of the tube (*b*) where the ocular is inserted, to the lower end (*d*) where the objective is screwed in, answer this requirement of simplicity. Without urging this as the best possible selection, it will readily be seen that this "tube-length" may be easily measured when the ocular and objective are not in position and that makers of stands who do not also make objectives could easily make the tubes of their microscopes of exactly the right length for the objectives of all objective makers. While it is true that the objectives of various makers are in mountings of different lengths, and, therefore, other things being equal, tend to increase or diminish the actual or "optical tube-length," and thus to vary the magnification of the Microscope, if each maker would choose the length designated above (*b-d*) for which to correct his objectives in their mountings, then no matter how long or short that mounting might be, the microscopist would be able to measure off the right length on the tube of his microsope for which the objective was corrected, and having this length once determined, it would not need to be changed when an objective of different length of setting was used.

Furthermore, the convenience of the microscopist and uniformity in "tube length" would be both subserved if the eye-pieces or oculars were made "*parfocal*"* "that is the settings be so adjusted that the lower focal points of all the eye-pieces shall be at the same level when in position in the tube of the microscope,"† then no refocusing of the microscope would be necessary upon changing oculars. If also the level of the "lower focal points" of the different oculars were made to fall at the level of the top of the body tube of the microscope, one end of the so-called "optical tube-length" would be always determinable, and correspond with one end, that is the upper end, of the tube of the microscope.

So long as no common standard is employed, it seems to the writer that every objective should be accompanied by a statement and a diagram indicating the tube-length in millimeters for which it was corrected, and showing also the parts of the microscope included in this measurement. If the objective is unadjustable, a statement should also accompany it, giving the thickness of cover-glass for which it was adjusted. (See below under II).

II. *The thickness of cover-glass for which unadjustable objectives are corrected.*

As the thickness of the cover-glass as well as the "tube-length" has an important influence on the perfection of the microscopic image, and as almost all objects for microscopic examination are covered, the objective must be adjustable to compensate for the various thicknesses of cover-glasses used, or some uniform thickness of cover-glass must be selected, for which the optician corrects or adjusts the objective once for all. The thickness for which such unadjustable objectives are adjusted varies with the different

* This convenient name was proposed by the editor of the *Microscopical Bulletin* in vol. iii. (1886) p. 31. See also p. 9, same vol.

† See page 8 of the catalogue sent out by Zeiss, with his apochromatic objectives and compensation oculars. Also *Jour. Roy. Micr. Soc.*, 1886, p. 853.

opticians, as shown in the table below. The information in the table was obtained by direct inquiry as for the information concerning "tube-length."

Table showing the thickness of cover-glass for which unadjustable objectives are corrected by various opticians:

$\frac{25}{100}$mm.	J. Green, Brooklyn. J. Grunow, New York. Powell and Lealand, London. H. R. Spencer & Co., Geneva, N. Y. W. Wales, New York.
$\frac{18}{100}$mm.	Klönne und Müller, Berlin.
$\frac{17}{100}$mm.	E. Leitz, Wetzlar (when tube 160–170 mm.).
$\frac{16\text{-}25}{100}$mm.	Ross & Co., London.
$\frac{16}{100}$mm.	Bausch & Lomb Optical Co., Rochester.
$\frac{15\text{-}20}{100}$mm.	C. Zeiss, Jena, $\frac{16}{100}$mm. (apochromatic oil immersions).
$\frac{15\text{-}18}{100}$mm.	C. Reichert, Vienna.
$\frac{15}{100}$mm.	Gundlach Optical Co., Rochester. W. & H. Siebert, Wetzlar. R. & J. Beck, London.
$\frac{12\text{-}17}{100}$mm.	J. Zentmayer, Philadelphia.
$\frac{10\text{-}12\frac{1}{2}}{100}$mm.	Nachet et Fils, Paris. Bézu, Hausser et Cie, Paris.
$\frac{10}{100}$mm.	Swift and Son, London.

A uniform thickness of cover-glass for unadjustable objectives seems also desirable; then by the use of some cover-glass measure, like the one made by Zeiss, the microscopist could easily select covers of the proper thickness to be used for the specimens to be studied with the unadjustable objectives of all opticians.

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